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A NOMOGRAM FOR THE CALCULATION OF DISSOLVED OXYGEN

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A NOMOGRAM FOR THE CALCULATION OF DISSOLVED OXYGEN

It can readily be shown that the dissolved oxygen content of a sample, as determined by the usual Winkler method, is given by the simple formula

$$U = \frac{200}{V} W \tag{1}$$

when U = The dissolved oxygen content in parts per million (milligrams per liter)

W = The required number of milliliters (c.c.'s) of 0.025 M thiosulphate

V = The volume in milliliters of sample titrated.

By inspection of equation (1) it is evident that the calculation is entirely avoided when the volume of iodine solution taken for titration corresponds exactly to 200 ml. of the original sample. When this is done the dissolved oxygen content in parts per million is numerically the same as the number of milliliters of 0.025 M thiosulphate required to reach an end-point. In order to obtain 200 ml. of sample it is necessary to measure out slightly more than 200 ml. of the iodine solution. For the particular case when 2 ml. of reagents are added to bottles of about 250 ml. capacity, the amount to be measured out in order to obtain 200 ml. of sample is

$$V = 200 \left(\frac{250}{250 - 2} \right) = 200 \ (1.00806) = 201.6$$

This slight correction is frequently disregarded, although it can be taken care of automatically by using volumetric flasks calibrated to hold 201.6 ml.

By reason of its simplicity it is believed that the method of computation just outlined is the one which is commonly used in most laboratories. In field work, however, and for special reasons in some laboratories, the more laborious procedure has been adopted of titrating the entire contents of a bottle. To facilitate the calculations, Pond and Gallagher (Department of Public Utilities, Cleveland, Ohio; private communication) have prepared 31 tables to cover bottle capacities from 240 to 270 ml. For a bottle of given capacity within

the stated range, these tables give the dissolved oxygen content which corresponds to titration values up to 11 or 12 ml. 0.025 M thiosulphate by increments of 0.1 ml. from zero.

If the entire contents of the bottle are to be titrated, it is more convenient and sufficiently exact to make use of a nomographic chart of the type shown in the accompanying chart. In this chart the net volume of sample titrated has been laid out on the right-hand scale. Without crowding, it was found possible to cover the range from 235 to 310 ml., comprising the usual variation in bottle capacities. The middle scale covers the range from 1 to 15 ml. of 0.025 M thiosulphate. The left-hand scale gives the desired parts per million of dissolved oxygen. The method of using this chart may be illustrated by the following example:

Let it be assumed that the capacity of the bottle with the stopper inserted is 252 ml. If 2 ml. of reagents have been used, the volume of original sample available for titration is 250 ml. If 5.0 ml. of 0.025 M thiosulphate are required to titrate the entire contents of the bottle, the dissolved oxygen content by equation (1) should be

$$U=\frac{200}{250}\times 5.0=0.8\times 5.0=4.0 \text{ p. p. m.}$$

Using the chart, the same information could be obtained by connecting the figure of 250 on the right-hand scale with the value of 5.0 on the middle scale, using a straight-edged ruler of celluloid or other transparent material for the alignment. The corresponding value of 4.0 parts per million could then be read off directly from the left-hand scale.

It will be noted that the scale for ml. of 0.025 M thiosulphate extends only to 1.0 ml. This does not introduce any difficulty, as the range of these logarithmic scales may be readily changed by dividing (or multiplying) the indicated figures by 10, with a corresponding change in the decimal place of the left-hand, or parts-per-million scale. Thus a reading of 0.50 ml. of 0.025 M thiosulphate gives 0.40 p. p. m. of dissolved oxygen. Correspondingly, a reading of 15.0 ml. of 0.025 M thiosulphate may be referred to the figure of 1.5 on the lower part of the scale. When the net volume titrated is 250 ml., the indicated parts per million would be 1.20, which should be read 12.0 to account for the change of scale.

For the construction of the chart to cover other ranges of bottle capacities, the reader is referred to Lipka, "Graphical and Mechanical Computation," p. 47, or to other standard texts on nomographic or alignment charts. In the accompanying chart the equations which represent the left-hand scale are $X=0$ and $Y=100 \log U$. This scale can be read directly from a table of logarithms. Using paper ruled 10 divisions to the inch, the middle scale is then laid off 10

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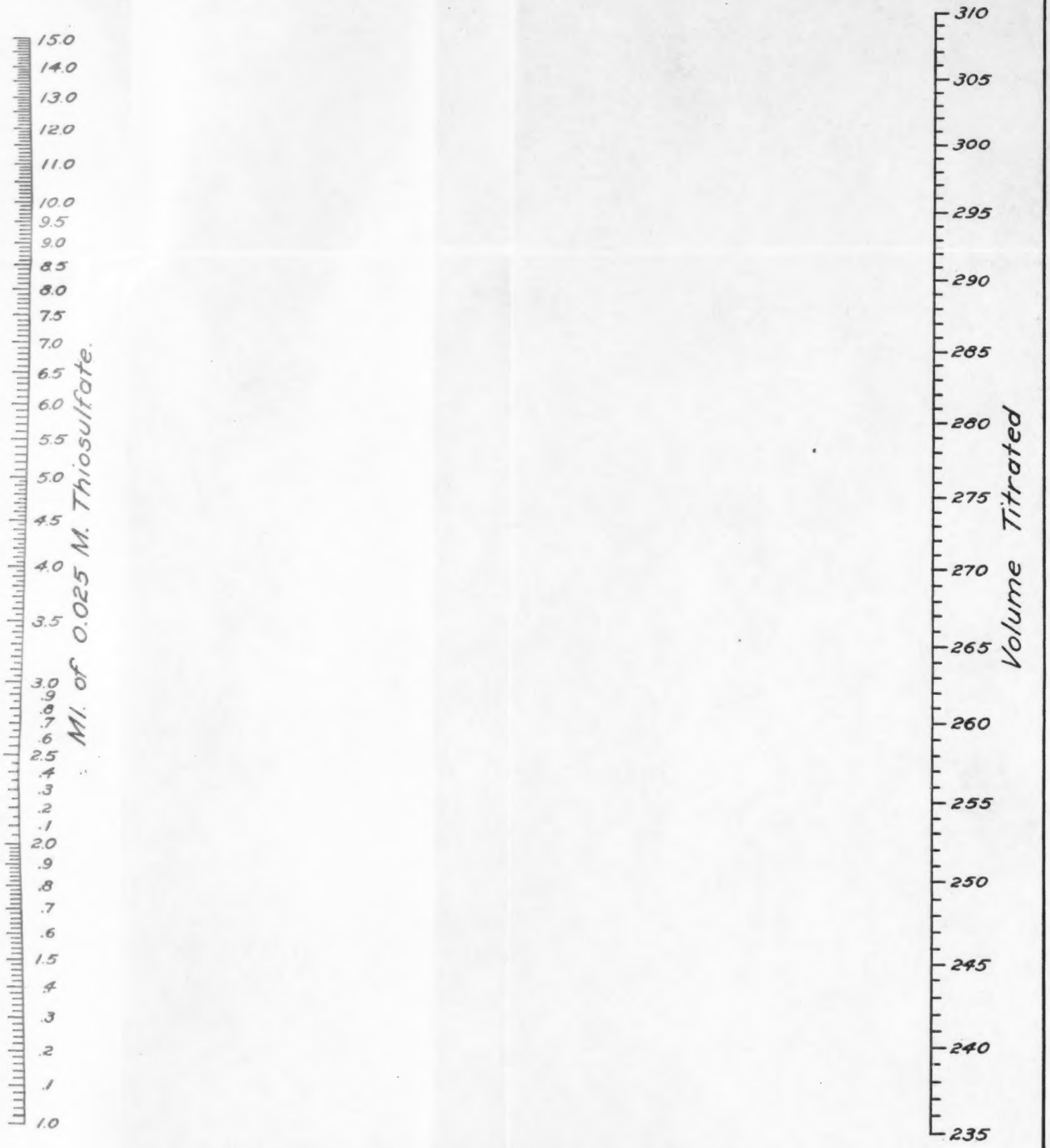

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NOMOGRAM FOR DISSOLVED OXYGEN DETERMINATION

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divisions to the right. The equations for this scale are $X=10$ and $Y=90 \log W-90 \log 1.2=90 \log W-7.13$. The corresponding equations for the right-hand scale are $X=100$ and $Y=900 \log \frac{V}{200} - 900 \log \frac{240}{200} = 900 \log \frac{V}{200}-71.3$.

In passing, it should be noted that the actual computation of the dissolved oxygen content may be unnecessary in oxygen demand work when the dilutions are prepared by the direct addition of the sample to incubation bottles which are then filled with dilution water of negligible oxygen demand. Let it be assumed that 2.5 ml. or some other convenient fraction of one liter have been added to each of two bottles of equal capacity. One of these bottles is dosed with 2 ml. of the usual Winkler reagents and the iodine liberated on acidification is titrated with 0.025 M thiosulphate using the entire contents of the bottle. A second bottle is incubated for 5 days before titration. Under the assumed conditions the oxygen demand of the sample could be derived as follows:

ml. 0.025 M thiosulphate required at start = 9.35
ml. 0.025 M thiosulphate required at finish = 3.10

6.25

Milligrams of oxygen for 2.5 ml. of waste $=0.2\times6.25=1.25$
Milligrams of oxygen for 1,000 ml. of waste $=1.25\times400=500$

The factor of 0.2 corresponds to the milligrams of oxygen represented by 1 ml. of 0.025 M thiosulphate solution. The exact volume of the bottles is immaterial provided that bottles of *equal* capacity are used. If the volume of the bottles is about 250 ml., a correction of 0.8 per cent may be applied by mental calculation to the final result as an allowance for the displacement of sample by 2 ml. of added reagents. The corrected oxygen demand in the above illustration would be 504 p. p. m.

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